

A
SHORT INTRODUCTION
TO THE
KNOWLEDGE
OF
GASEOUS BODIES.



A
SHORT INTRODUCTION
TO THE
KNOWLEDGE
OF
GASEOUS BODIES.

By Dr. A. N. SCHERER.

PROFESSOR OF CHEMISTRY, AND COUNSELLOR
OF MINES TO HIS SERENE HIGHNESS THE
DUKE OF SAXE-WEIMAR.

— Und wenn natur dich unterweis't,
Dann geht die Seelenkraft dir auf —
FAUST.

TRANSLATED FROM THE GERMAN.

London :

Printed by J. W. MYERS, No. 2, Paternoster-row ;

FOR W. TREPPASS, ST. MARTIN'S-LE-GRAND ;
HATCHARD, PICCADILLY ; AND MANNERS
AND MILLAR, EDINBURGH.

1800.

P R E F A C E.

CHEMISTRY is at present enriched by so many new discoveries and facts, and its influence upon the arts is so extensive, that its more general cultivation cannot be otherwise than highly beneficial to society.

Persuaded of this truth, his Serene Highness the Duke of SAXE-WEIMAR, whose love for the Sciences is well known,

known, directed me to contribute to the advancement of Chemistry, by means of public lectures. I received this order with the greater pleasure, being aware that scientific lectures of this nature are seldom delivered any where else than at Universities, and other learned Institutions.

No object in Chemistry appeared to me of more importance, nor more applicable to the various purposes of life, than the doctrine of Gaseous Bodies. I was induced, therefore, to make it the subject of the lectures which I commenced in the beginning of this year before a very numerous assembly, and which I still continue to this day, without interruption. That I might
proceed

proceed in a certain systematical order, and enable my auditors, in some measure, to obtain a general view of the subjects treated of, and, moreover, to fix their attention to certain points, I thought proper to sketch the following sheets, which, in as narrow a compass as possible, contain the principle heads of the Science. I need not observe, that, on account of so mixed an audience, (for, agreeably to His Highness's pleasure, all ranks of society, men and women, are admitted) I am obliged to leave almost every thing to verbal explanation. The end of such sketches is attained, when, by the bare exhibition of names and facts, retrospective tables, and the like, we guide the progressive steps of the student, and enable him to

fix

fix in his mind the subjects previously treated of. In these sheets I have just glanced at some of the most important applications of the facts discovered: a detailed account of them, as well as of their connection with all other branches of Chemistry, I reserve for my lectures.

The longer I enjoy the happiness of thus contributing by public lectures to the advancement of a science to which I have dedicated my whole life, the more I am convinced, that such public instruction does not gain, in point of utility, by an affected popularity, but solely by the rigid systematical order in which the subjects are discussed. And what can be more agreeable to the human

human mind? This conviction bears the stronger upon me, as I have thus succeeded in this new attempt to render myself useful by clearing up many difficult points.

Having thus spoken of the occasion that gave rise to this work, I think I have also determined the point of view in which it ought to be considered, if at all it should be thought worth notice.* I shall think myself happy, if,

* I cannot in this place enter into a justification respecting the classification of undecomposed substances, p. 33. and the degradation of oxygen gas, p. 43. I had my reasons for adopting this order. Respecting the latter, I have explained myself in my additions to Cavallo's Essay, on the Medical Application of Gases.

in the History of Chemistry, it furnish an additional proof of the laudable zeal with which this science is now cultivated.

A. N. SCHERER.

WEIMAR, 1799.

CONTENTS,

C O N T E N T S.

	Page.
<i>A CURSORY view of the History of Chemistry</i>	17

INTRODUCTION.

<i>A synoptical view of the principal Theorems in Chemistry</i>	31
---	----

FIRST SECTION.

<i>Consideration of Gases in general</i>	38
--	----

SECOND SECTION.

	Page.
<i>Of the Decomposition of atmospherical Air, and the Examinations therewith connected</i>	45
I. <i>Analysis and Composition of atmospherical Air</i>	ibid.
II. <i>A more minute View of the constituent Parts of atmospherical Air</i>	50
A. <i>Oxygen Gas</i>	ibid.
B. <i>Nitrogen Gas</i>	52
III. <i>Application of the preceding Facta to various Phenomena</i>	54.
A. <i>Theory of Combustion</i>	ibid.
B. <i>Nature of Acids</i>	55
C. <i>Generation of the nitric Acid; Nature of nitrous Gas, and of nitrous acid Gas</i>	58
1. <i>Nitric Acid</i>	ibid.
2. <i>Nitrous Gas</i>	59
3. <i>Nitrous</i>	

CONTENTS.

xiii

Page.

3. <i>Nitrous acid Gas</i>	62
D. <i>Concerning Endiometers</i>	63

THIRD SECTION.

<i>Examination of the adventitious</i>	
<i>Parts of atmospherical Air</i>	65
I. <i>Concerning carbonic acid Gas</i>	66
II. <i>Concerning Water</i>	72
<i>Hydrogen Gas</i>	76
<i>Application of the preceding Experi-</i>	
<i>ments to other Phenomena</i>	78
1. <i>Detonation</i>	ibid.
2. <i>Gunpowder</i>	ibid.

FOURTH SECTION.

<i>Examination of compound inflam-</i>	
<i>mable Gases</i>	79
I. <i>Carbonated hydrogen Gas</i>	80
II. <i>Sul-</i>	

II. <i>Sulphurated hydrogen Gas</i>	Page. 81
III. <i>Phosphorated hydrogen Gas</i>	83

APPENDIX.

IV. <i>Ammoniacal Gas</i>	85
<i>Application of these Facts to the Explanation of some Phenomena</i>	87
I. <i>General Law of Deoxygenation</i>	ibid.
II. <i>Nature of compound Acids</i>	88
III. <i>Composition of some inflammable Bodies</i>	92
1. <i>Spirit of Wine</i>	ibid.
2. <i>Oils</i>	ibid.
IV. <i>Constituent Parts of organized Bodies</i>	93
V. <i>Respecting the Mixture of the constituent Parts of organized Bodies</i>	95
VI. <i>Respiration</i>	97
a. <i>Of Animals</i>	ibid.
b. <i>Of Vegetables</i>	98

FIFTH SECTION.

	Page.
<i>Nature of acid Gases</i>	100
I. <i>Sulphurous acid Gas</i>	ibid.
II. <i>Phosphorous acid Gas</i>	101
III. <i>Muriatic acid Gas</i>	102
IV. <i>Oxygenated muriatic acid Gas</i>	ibid.
V. <i>Fluoric acid Gas</i>	108
<i>Application of the Properties of the</i> <i>Bodies just treated of</i>	109
I. <i>Bleaching</i>	ibid.
II. <i>Aqua Regia</i>	110

ERRATA.

Page		<i>for</i>		<i>read</i>
17	—	acquainted	—	acquainted
23	—	independant	—	independent
52, 83	—	synonimous	—	synonymous
54	—	phenomina	—	phenomena
In a few places	-	encrease	—	increase

A
CURSORY VIEW
OF THE
HISTORY
OF
CHEMISTRY.*

IT cannot be doubted that the celebrated nations of antiquity were acquainted with many chemical processes ; for we find that they possessed the art of making glass, of imitating precious stones, &c. But it is natural to suppose that a science so extremely intricate, so much depending upon the experience of ages, and on the state of the arts, was

The state of chemistry among the antients,

* This sketch of the History of Chemistry is not contained in the original, and has been added by the translator, in hopes that it may prove both useful and interesting to those who are just entering on the study of chemistry.

C

then

then but in its infancy. Accordingly, among the remains of Greek literature, there is not a single work which treats on chemistry in the sense in which this word is now understood, or, which mentions, its having ever been cultivated as a distinct science. But the obvious difference in the nature of the bodies that surround us, could not escape the notice of a people of so philosophical a turn of mind as the Grecians; hence both Aristotle and Empedocles taught the doctrine of the four supposed elements, fire, air, earth, and water.

Nor does it appear that the Romans, who derived their arts and sciences from the Grecians, were more acquainted with chemistry than their masters.

The first chemical writer that excites our notice is Geber, who is supposed to have lived about a century after Mahomet.

met. Many processes in his treatises are so well described, that we have every reason to think chemistry was then cultivated with considerable success. After the destruction of the Alexandrian library, natural philosophy, of which chemistry forms a part, was much studied by the Saracens; and as early as The Saracens. the tenth century chemists were acquainted with the muriatic acid, the method of decomposing culinary salt, and of oxidating mercury.

Metals, and several other substances, were then, and for some centuries after, supposed to be composed of salt, sulphur, and mercury; and all phenomena in chemistry were referred to this theory.

It would surpass our limits were we to give a minute detail of all the discoveries made subsequent to this period,

by many eminent chemical philosophers; we shall therefore only briefly relate what appears most worthy of our attention.

Valentine.

Basil Valentine, in the beginning of the fifteenth century, wrote a famous treatise, entitled, *Currus Triumphalis Antimonii*. He prepared sublimated muriate of antimony, the sulphurous, nitrous, and muriatic acids, and describes the method of making corrosive sublimate and cinnabar. He is an eminent admirer of the hypothesis of salt, sulphur, and mercury. At that time the grand object of chemistry was transmutation of metals, and the means of discovering an universal menstruum; and although the effort of the chemist, in his search after these desiderata, proved in the end unsuccessful, yet they led, in some measure, to the great number of discoveries by which this and the succeeding century are distinguished.

About

About this time flourished the famous Paracelsus,* perhaps one of the most extraordinary characters that ever lived. Paracelsus
born 1494,
died 1541.

He was possessed of a very acute and vigorous mind, and from his youth he distinguished himself by his ardent pursuit of knowledge. His theory was that of salt, sulphur, and mercury, of some modification of which he supposed all bodies to be composed. At this time there had existed three grand theories, which, according to their authors, were capable of being equally referred to for the explanation of all chemical phenomena. That of Thales supposed all bodies to originate from some peculiar arrangement of the particles of water: Secondly, the theory of the common elementary parts of bodies, which had existed even previous to the time of Empedocles and Aristotle: And, thirdly,

* His real name was Hockens.

that

that of salt, sulphur, and mercury. Paracelsus exhibited ether, lime, saline solutions, and carbonic acid, or fixed air.

Bacon.

A little more than a century after appeared the great Lord Chancellor Bacon, a man, not only eminent for his knowledge of chemistry, but also for his cultivation of various other parts of natural science. His peculiar mode of investigating nature proved highly advantageous to succeeding philosophers; and it is doubtful whether many branches of science would have advanced to their present state of perfection had not he pre-existed.

Ray.

Ray first observed the increased weight of metals, during calcination, a fact of the greatest moment to the progress of philosophic chemistry.

We

We should also mention the name of ^{Mayow.} Mayow, who set it down as a fact, that nitre cannot be formed without the presence of atmospherical air, or that part of the atmosphere which enables bodies to burn; that this part is absorbed during its formation, and again separated by combustion. He is also the inventor of a pneumatic apparatus.

Boyle, the cotemporary of Mayow, ^{Boyle.} was a nobleman of independant fortune, which he almost entirely bestowed on the pursuit and study of natural philosophy. Mayow and he are considered as the best chemists of the latter end of the seventeenth century, whom England could boast. He discovered the absorption of air in metallic combinations and oxidations.

Homberg, who lived about the same ^{Homberg.} time, discovered among other facts, that
light

light is absorbed during the oxidation or calcination of metals. He is celebrated also for his enquiries respecting phosphorus, &c.

Becher.

The next famous chemist is Becher of Spire, who distinguished himself so highly by his chemical knowledge, as to cause the names of all former theorists to be forgotten. He has anticipated many discoveries which have been successfully made since he wrote, and has laid the foundation to the famous system of phlogiston. He supposed the phlogistic sulphur of the alchemists to be the principle of combustion. He also introduced another famous hypothesis, viz. that the principle of inflammability in combustible bodies was owing to an earth *sui-generis*, which he denominated inflammable earth; saying, that fire was the effect of this substance, or a necessary consequence of its being put in motion.

At

At this period, independent of the alchymists, there existed three distinct classes of chemists; viz. the philosophical, technical, and pharmaceutical. That class who applied chemistry to natural philosophy were called philosophical chemists; secondly, technical chemists were those who wrote on chemistry, and applied it to the arts in general; thirdly, the pharmaceutical chemists wrote upon the use of chemistry in medicine.

We shall now speak of the celebrated Stahl, the pupil of Becher, whom he Stahl equalled in point of genius. He contended that the principle object of chemistry was to explain the phenomena of those phlogistic principles, which, according to him, exist in all combustible bodies, but more especially in metals, and, that when this principle is separated, there appears fire. This

D

seems

seems to have been somewhat like the abscondita flamma of the antients, or the supposed hidden or combined flame of Lucretius. He insisted that one component of metals, in their metallic state, consists of a peculiar body and phlogiston; that when calcined they lost such phlogiston, and regained it on being reduced to their metallic state, and that this was effected by the addition of combustible matter. He differs from Becher in maintaining that the combustible principle exists in bodies in a state of rest, and that it produces heat then only when in a state of motion. His words are, "*est solum ad ignis motum accommodatum creatum et aptum, est ignis corporeus, vel ipsa præcise propria materies ignis.*" Stahl is the first who had a clear notion of chemical union, and gives many instances of double elective attractions, which are the basis of all chemical reasonings. In the

the number of his inventions he is scarcely exceeded by any chemist. His writings have done him immortal honor, and ranked him among the first characters of the age in which he lived. He died in 1734.

His death.

Since his time many philosophers, of the deepest penetration have applied themselves with success to the study of chemistry; their accurate method of analysis, and their great progress in investigating the affinities of bodies, have led to the discovery of many of those numerous and important facts with which chemistry is now enriched. The names of Geoffroy, Margraaf, Macquer, Schcele, Bergman, and others, will ever remain distinguished in the annals of chemical science.

Before we conclude this cursory view of the history of chemistry, it will be pro-

Lavoisier.

per to speak of the labours of the French chemists, and particularly of the celebrated Lavoisier, which led to the overthrow of the system of Stahl, and to the erection of that luminous theory which is now almost universally adopted. Endowed by nature with the most happy genius for science, and favoured by his own princely fortune, and the liberal bounty of the French government, he proceeded to the most scrupulous examination of all that was then known in chemistry. He discovered a multitude of new facts, and proved to demonstration, that the theory of phlogiston is founded in error; that the combustion of bodies, and the calcination of metals, is not owing to the disengagement of phlogiston, but to the absorption of that part of the atmosphere which he denominated oxygen. He reformed the nomenclature of chemical substances, hitherto distinguished by its
 inceno-

incongruity, and introduced a mode of reasoning in chemistry, which cannot fail of adding to the further advancement of a science which has such an extensive influence on our enjoyments, and upon our knowledge of the works of our creator. What a pity that the sanguinary tyranny of Robespierre should not even have spared this man!

Since his death, up to the present time, chemistry has been cultivated with great success in every part of Europe, but more particularly in France, England, and Germany.

The study of this science is now no longer confined to a particular class of individuals; its beneficial influence upon the arts and manufactories, which is felt more and more every day, has given birth to a number of periodical publications, by which a knowledge

ledge

ledge of chemistry, and of other branches of natural philosophy, is disseminated, at a cheap rate, among all ranks of society; and much to the credit of the age in which we live, they meet with that liberal encouragement to which they are so justly entitled. But this is not all: in almost every country of Europe, philosophical establishments are now forming, under the direction of men of science, with a view of giving the public an opportunity of acquiring a knowledge of those branches of chemistry, most applicable to their different professions. An institution of this nature has lately been founded in London, under the patronage of his Majesty, upon the plan of that distinguished literary character Count Rumford, which promises to accomplish the noble purpose for which it was originally designed.

INTRODUCTION.

A Synoptical View of the principal Theorems in Chemistry.

I.

CHEMISTRY is employed upon the examination of the component parts of natural bodies.

II.

Component, or constituent parts of a compound body, are particles whose properties neither resemble each other, nor the properties of the mass from which they were derived. They are considered

dered as heterogeneous. When united, so that the whole appears uniform, they form mixtures, otherwise heaps.

III.

Their various combinations are the result of an innate power which they possess, entirely unknown to us, commonly termed affinity. So also their separation depends upon the manner in which this power is manifested.

IV.

All chemical operations are founded upon combinations and separations.

V.

These enable us at length to discover those constituents of bodies which cannot be further formed from heterogeneous
ous

ous particles, and which extend throughout the whole mass. They are denominated primary matter, undecomposed substances, and were formerly termed elements.

VI.

UNDECOMPOSED SUBSTANCES*:

- I. *Ascertainable by Weight alone, but not otherwise perceived by the Senses.*
 1. Oxygen.
 2. Azot or nitrogen.

* Light and caloric, or the matter of heat, have by many authors been classed among simple or undecomposed substances; but whether they be substances at all is a question not yet decided. It is certain, however, that both light and heat have many properties in common with physical bodies, thus light is known to possess elasticity, to have chemical affinities, and to produce a remarkable change upon vegetables, which are not matured without its influence. On the subject of heat see *the Writings of Count Rumford*. T.

- 3. Hydrogen.
- 4. Carbon.

II *Perceptible by the Senses.*

A *Insoluble in water.*

i *Not permanent in fire.*

a *Highly inflammable.*

- 5 Sulphur.
- 6 Phosphorus.

b. *Difficultly inflammable: Metals.*

- 7. Gold.
- 8. Platina.
- 9. Silver.
- 10. Mercury.
- 11. Lead.
- 12. Bismuth.
- 13. Copper.
- 14. Arsenic
- 15. Iron.
- 16. Cobalt.

- 17. Nickel*.
- 18. Tin.
- 19. Zinc.
- 20. Antimony.
- 21. Manganese.
- 22. Molybdena.
- 23. Tungsten.
- 24. Uranite.
- 25. Titanite†.
- 26. Tellurite.
- 27. Chromite.

2. *Permanent in the Fire*: Earths.

- 28. Alumin.
- 29. Silex.
- 30. Jargon.

* This body has been accidentally omitted in the original. T.

† This, and the two following metals, have been discovered within these two or three years past. T.

- 31. Talc.
- 32. Glucine*.

B. *Soluble in Water: Alkalis.*

- 33. Vegetable alkali, or pot-ash.
- 34. Mineral alkali, or soda.
- 35. Lime.
- 36. Baryt.
- 37. Strontian†.

III. *Substances as yet unknown, but analogically considered as simple.*

- 38. The radical of the muriatic acid.
- 39. ————— fluoric acid.
- 40. ————— boracic acid.

* This earth has been lately discovered.

† Discovered a few years since in the mines of Strontian, in Argyleshire.—*Vide the Trans. of the Royal Society of Edinburgh.* T.

VII.

In every chemical analysis, or decomposition of bodies into the constituent parts before mentioned, it is necessary that their state of aggregation be previously destroyed. By this is meant the state of solidity, fluidity, vapour or steam, and gas, under which bodies appear.

VIII.

The most simple chemical processes consist in solution and precipitation. By the former dissimilar parts are united into one homogeneous mass; by the latter they are separated, after such union has taken place.

FIRST

FIRST SECTION.

Consideration of Gases in general.

IX.

By the word gas we distinguish every permanent elastic fluid which possesses gravity, is colourless, transparent, invisible, and which can be included in vessels.

X.

Many of the substances by which we are surrounded are capable, under certain circumstances, of entering into the state of gas. This change is effected chiefly by all those operations which promote the disengagement of heat.

XI.

By the terms heat and cold we express certain sensations well known.
The

The former denotes the presence of heat, the latter its absence. The cause by which heat is produced is entirely unknown, but we are acquainted with the

XII.

Laws agreeably to which the Phenomena of Heat are manifested.

They are:

1. All bodies, according to circumstances, are capable of producing heat.

2. Heat expands bodies in every direction.

3. Bodies exposed to heat seem to destroy it, or, in other words, to take up the cause by which heat was excited.

4. All

4. All bodies do not produce this effect in the same manner: hence they are said to have different capacities for heat.

5 Nor are all bodies equally penetrable by heat. A body which admits it more readily than others is, therefore, considered as possessing a greater power of conducting heat*.

6. Finally, heat exhibits a tendency to establish an equilibrium in all bodies.

* From the late accurate and satisfactory experiments of the ingenious Count Rumford, it appears that water is a perfect non-conductor of heat, and that heat is propagated in it only in consequence of the motions, which the heat occasions in the insulated and solitary particles of the water, by altering their specific gravities.—*Vide Count Rumford's Essays, Vol. II. T.*

XIII.

The expansive power of heat enables us to determine its intensity by means of instruments, called Thermometers and Pyrometers.

XIV.

In consequence of the property observed XII. No. 3, we make use of the expressions free and combined heat. The former is discovered by the instruments before-mentioned (XIII.)

XV.

With respect to the capacity of bodies for heat, or, their property of entering into combination with it, we perceive, moreover, the following laws:

1. Heat is excited whenever a body, more or less fluid, enters into a state of greater or less solidity ; or, bodies, by undergoing this change in their form, diminish their capacity for heat.

2. Cold is produced in all cases where bodies change their more or less solid form, for one more or less fluid ; or, they increase their capacity for combining with heat.

XVI.

Those gases which are generated from various substances, chiefly by the effect of heat, are not contained in those substances in the state of gas, but owe their formation to the expansive property of heat.

XVII.

The preparation of gases requires peculiar instruments, which are comprised
under

under the name of the Pneumatic Apparatus. It consists of Pneumatic Tubs, Retorts, Gasometers, Receivers, &c.

XVIII.

ENUMERATION OF THE GASES AT PRESENT KNOWN.

They are:

I. *Respirable.*

1. Atmospheric air.

II. *Unrespirable, or mephitic.*

a. *Inflammable:*

1. *Miscible with water:*
 2. Sulphurated hydrogen gas.
 3. Ammoniacal gas.

2. *Immiscible with water:*

4. Hydrogen gas.

5. Carbonated hydrogen gas*.
6. Phosphorated hydrogen gas.
 - b. *Gases promoting flame:*
 1. *Immiscible with water.*
7. Oxygen gas.
 2. *Miscible with water.*
8. Oxygenated muriatic acid gas.
 - c. *Uninflammable:*
 1. *Miscible with water:*
9. Carbonic acid gas.
10. Muriatic acid gas.
11. Sulphurous acid gas.
12. Fluoric acid gas.
13. Phosphorous acid gas.
14. Nitrous acid gas.
 2. *Immiscible with water,*
15. Nitrogen gas.
- 16 Nitrous gas,

* Carbonated hydrogen gas is said to exist in some mineral waters in Italy.—*Vide Kirwan's Essay on the Analysis of mineral Waters. Chap. 1. page 12. T.*

SECOND

SECOND SECTION.

Of the Decomposition of Atmospheric Air, and the Examinations therewith connected,

1. Analysis and composition of atmospheric Air.

XIX.

Atmospherical air has evidently an influence upon a great number of bodies.

XX.

Of this the combustion of bodies furnishes the most sudden and striking instance.

XXI.

Does here the burnt body act alone, or does combustion depend solely on the co-operation

co-operation of atmospherical air? This query is resolved by the following

XXII.

Comparison of the Phenomena observed during Combustion.

I. No combustion takes place unless the temperature of the combustible body be increased.

II. No combustion ensues without the presence of atmospherical air, or its respirable part.

III. The freer the access of air the more rapid will be the combustion of bodies.

IV. In a determined quantity of atmospherical air only a determined quantity of the combustible body can be burnt.

v. The

v. The air, in which a body is burnt, decreases in volume and weight.

vi. The burnt body, on the contrary, increases in weight, provided no volatile matter is disengaged during combustion.

vii. The increase of weight, in the burnt body, is precisely equal to the decrease of the air in which the combustion of the body took place.

viii. The air, which remains after combustion, is no longer fit for the support of flame.

ix. Frequently an acid is produced during the combustion of a body.

XXIII.

Hence it follows:

i. That atmospherical air necessarily contains some substance, without the co-operation

co-operation of which no combustion is possible. (*Vide* 22. II. III.)

2. That during combustion the combustible body enters into combination with that substance. (*Vide* 22. V. VI. VII. IX.)

3. That that unknown substance is capable, under certain circumstances, of forming an acid with the combustible body. (*Vide* 22. IX.)

4. That that substance is combined, in the atmosphere, with something possessing very different properties. (*Vide* 22. VIII.)

XXIV.

Proof of the foregoing Deductions.

This necessarily consists in depriving the inflammable body, after its combustion

tion, of the unknown substance before mentioned, in order to recompose atmospherical air, by combining it with that part of the atmosphere which remained after combustion. (22. v.)

XXV.

Application of this Proof.

We may apply the foregoing proof by attending to those phenomena which are perfectly analogous to combustion. Among these, the most remarkable is, what is commonly termed, the calcination of metals, or, in other words, that change of metals, in an intense heat, nourished by the free access of air, by which they lose all their characteristic properties as metals.

During this change precisely the same circumstances and conditions take place that were mentioned, xxii; except, that

G

with

with respect to metals, we are fortunately able to deprive them of the substance with which they entered into combination, which process is termed, Reduction of Metals.

Now, if the gaseous substance, obtained by the preceding operation, be combined with that part of atmospherical air, which was left during the calcination, the product will be, Atmospherical Air.

II. *A more minute View of the constituent Parts of Atmospherical Air.*

A. *Oxygen Gas.*

XXVI.

It is necessary that we should enter into a more minute investigation of that part of atmospherical air, which combines with metals, during their calcination,

tion, and which is capable of being again separated, after such combination has taken place.

We obtain it in the form of gas, if any metallic calx (especially that of manganese) be exposed to a red heat.

It is distinguished by the following properties:

1. It is heavier than atmospherical air.*

2. It has neither smell, taste, nor acid properties.

3. It is favourable to respiration; and promotes, in an eminent degree, the calcination of metals, and the combustion of combustible matter.

* Its specific gravity to that of common air is as 1103 : 1000. A cubic inch weighs 0,50694 of a grain.—*Vide Jacquin. T.*

4. It is totally absorbed during the burning of phosphorus.

5. The burnt phosphorus is entirely converted into an acid.

XXVII.

On account of the remarkable property of this gas, to form an acid with the burnt body, Lavoisier was induced to distinguish its basis by the name of Generator of Acid, or Oxygen, and its elastic fluid state, in consequence of the influence of heat, Oxygen Gas.

Synonymous terms are, Vital air, Fire air, Dephlogisticated air, Pure air.

B. *Nitrogen gas.*

XXVIII.

As it appears from the foregoing observations that only the oxygen of the
atmos-

atmosphere combines with the combustible matter, it is requisite that we should likewise examine that part of atmospherical air, which remains unaffected during combustion. (22. VIII.)

We therefore separate it from the oxygen of atmospherical air, by the combustion of inflammable bodies.

This gas differs from oxygen gas by its opposite properties; that is, it is incapable of supporting combustion and the respiration of animals. Moreover, it is lighter than atmospherical air,* and unites with the oxygen gas of the atmosphere.

On account of its incapacity of maintaining animal respiration, it is termed,

* Its specific gravity to that of common air is 985 : 1000. A cubic inch weighs 0,44444 of a grain.—*Vide Jacquin.* T.

Unrespi-

Unrespirable air, Suffocating air, &c. Its basis, which becomes gas by the action of heat, is called azot or nitrogen.

The constituent parts of atmospherical air are, therefore, oxygen and azot.

III. *Application of the preceding Facta to various Phenomina.*

A. *Theory of Combustion.*

XXIX.

The cause of combustion rests, therefore, in the reciprocal action of oxygen upon the combustible body, which action, according to its energy, is accompanied, more or less, by the phenomena of light and heat: On these occasions the combustible body always combines with oxygen. Combustions, and all those operations by which we effect the combination of a body with oxygen, are, therefore, termed Oxidations. Those processes

cesses by which, on the contrary, we deprive a body of its oxygen, are termed Deoxygenations*.

XXX.

These results will enable us to account for the usual mode of producing heat, by the burning of combustible bodies, such as wood, coals, &c. I shall, therefore, in my lectures, enter more largely on the construction of ovens, and the economical use of fuel.

B. *Nature of Acids.*

XXXI.

Acids, or those compounds distinguished by their sour or acid taste, and their action upon vegetable colours, consist, as appears from the foregoing exa-

* The term deoxygenation has been preferred, as being more common; but deoxidation would be equally proper. T.

minations (xxii. 9. xxiii. 3. xxvi. 4. xxvii.) of the acidifying principle or oxygen, and a body which bears an affinity to it. The latter is, therefore, denominated the Radical or Basis of the acid. Substances, not acids, though combined with oxygen, are termed Oxides.

XXXII.

A great variety of substances are capable of combining with oxygen. The difference between one acid and another is owing to the peculiar nature of the radical.

XXXIII.

Acids are either simple or compound*. Among the former we reckon the sul-

* By the term simple acid is meant an acid, of which the basis or radical consists of but one substance. The radicals of compound acids, which are chiefly those of the vegetable and animal kingdom, consist, on the contrary, of more than one substance, as hydrogen and carbon. T.

phuric

phuric acid, nitric acid, phosphoric acid, carbonic acid, arsenic acid, molybdic acid, tungstic acid, chromic acid.

The radical of some acids is as yet entirely unknown, as the radical of fluoric acid, boracic acid, muriatic acid.

XXXIV.

The radicals of acids combine with the acidifying principle, or oxygen, in various proportions.* If the union of both substances be such as to produce a true chemical compound (II.) the acid is said to be perfect; in the contrary case, it is considered as imperfect. The former is now generally distinguished by the syllabic inflexion *ic*, and the latter by *ous*; thus we have the *nitric* acid and the *nitrous* acid; the *acetic* acid, and the *acetous* acid, &c.

* The radicals of some acids admit of a fourth degree of oxidation.

XXXV.

Acids united with alkalis, earths, and metallic oxides, form compounds termed Salts.

C. *Generation of the Nitric Acid, Nature of Nitrous Gas, and of Nitrous Acid Gas.*

1. *Nitric Acid.*

XXXVI.

During the putrefaction of organized substances, especially those of animals, there is generated an acid which, uniting with the lime of the earth or mould, forms crude nitre, or salt petre.* From

* Artificial nitre-beds are commonly formed of rubbish, ashes, lime, the ordure of stables, putrescent vegetable matter, &c. From this mixture, when sufficiently impregnated, the nitre is obtained by lixiviation. In some countries it is produced spontaneously on the surface of the earth, as in some parts of the East Indies and Italy, the Russian Ukrain, &c. T.

this

this the acid may be separated by the vegetable alkali or potash, with which it forms nitre or saltpetre; the acid is therefore termed the Nitric acid.

XXXVII.

This acid is also obtained if the bases of the two gases which compose the atmosphere, viz. oxygen and nitrogen, or a mixture of $20\frac{1}{2}$ parts of nitrogen gas, and $79\frac{1}{2}$ parts oxygen gas (by weight) be forced to assume a liquid form, which is effected by conducting a stream of electric sparks through it.

2. *Nitrous Gas.*

XXXVIII.

If oxidifiable substances, for instance metals, (copper) be dissolved in nitric acid, they deprive it of part of its oxygen, and what remains escapes in

combination with the nitrogen, in the form of gas. This gas is termed Nitrous gas, or Nitrous air.

XXXIX.

The most remarkable character of this gas is, that on the contact of atmospherical air, it immediately loses its gaseous form, and changes into reddish-yellow acid fumes, which are nitrous acid, consisting of 75 parts oxygen and 25 parts nitrogen or azot, and which are gradually absorbed by water. Both these occupy a less space, and nitrous gas only remains. This phenomenon is still more striking in oxygen gas: if a pint of oxygen gas be mixed with two pints of nitrous gas, they almost entirely disappear.

XL. This

XL.

This gas is further distinguished by the following properties:

1. It is colourless, and has neither taste nor smell.
2. It does not possess any acid properties.
3. It is insoluble in water.
4. It is unfit for respiration, or the support of flame.
5. It is heavier than atmospherical air.*

XLI.

This gas has a compound basis, consisting of oxygen and nitrogen, or azot, in the proportion of about 68 of the former to 32 of the latter.

* Its specific gravity to that of the atmosphere is 1,195: 1000. A cubic inch weighs 0,54690 of a grain. *Vide* Jacquin. T.

Nitrous

Nitrous Acid Gas.

XLII.

If nitrous gas be kept for some time over iron filings, previously moistened, it suffers a diminution of volume of about $\frac{2}{3}$, and obtains very different properties; the iron being oxidated in the mean time. (XXIX.)

XLIII.

The remainder of the gas is distinguished by the following properties :

1. It is capable of absorption by water.
2. Neither atmospherical air, nor oxygen gas, produces any change in it, nor do they form red vapours on contact with it.
3. A taper burns in it with encreased lustre, and its glowing wick speedily exhibits a brilliant flame.
4. But

4. But it extinguishes burning phosphorus, sulphur, and carbon, and destroys animal life.

5. Nitrous gas has no action upon it.

In other respects it is neither acid to the taste, nor does it possess any external property by which it might be distinguished from nitrous gas; it is termed Nitrous acid gas.

XLIV.

The basis of this gas is likewise composed of nitrogen and oxygen; but here the proportion of both is very different from that in nitrous gas, it being 63 of the former and 37 of the latter, in one hundred parts.

D. *Concerning Eudiometers.*

XLV.

As atmospherical air is fit for respiration solely on account of the quantity of oxygen gas it contains, it is highly important that we should be able, as
circum-

circumstances occur, to ascertain its proportion with accuracy. This is effected by all substances capable of depriving atmospherical air of its oxygen. Instruments adapted to these investigations are termed Eudiometers.

XLVI.

The substances most fit for the purposes of eudiometry are nitrous gas, (XXXIX.) phosphorus, and several other bodies.

XLVII.

The proportion of oxygen and nitrogen gases, in one hundred parts of atmospherical air, differs from 23 to 29 of the former, and from 77 to 71 of the latter.

That there may be various proportions of oxygen and nitrogen we have seen by our former examinations. (*Vide* XLVII. XXXVII. XXXIX. XLI. XLIV.)

THIRD

THIRD SECTION.

*Examination of the adventitious Parts of
Atmospherical Air.*

XLVIII.

Since a great variety of bodies perform their actions upon each other in atmospherical air, it is evident, that besides the essential constituents before mentioned, we may meet with many other substances in the atmosphere, which, though not abounding at all times in the same proportion, have, nevertheless, a very important influence upon it.

XLIX.

These substances are chiefly water and carbonic acid gas.

I

I. *Concerning*

I. *Concerning Carbonic Acid Gas.*

L.

Carbon suffers no change in the most violent heat, provided it be confined in a close vessel. It is converted into ashes then only when atmospherical air has free access. Now, as this air maintains combustion solely by reason of its proportion of oxygen, the examination of its properties, with respect to this substance, will necessarily furnish us with the safest clue for accounting for all the changes to which it is liable.

LI.

Formation of Carbonic Acid Gas.

If a coal, well charred, be burnt over mercury, in a bell glass, filled with oxygen gas, we find:

1. That

1. That the gas does not disappear as during the combustion of phosphorus, (*Vide* XXVI, 5.)

2. But the oxygen gas is entirely changed, so that it no longer possesses the property of maintaining combustion and respiration.

3. It encreases considerably in weight, and

4. Is now absorbed by water, but more readily by a solution of vegetable alkali, and by lime water, which is thus rendered turbid.

5. The coal decreases in weight.

6. This loss of the coal, and the encreased weight of the degenerated oxygen gas, gives the quantity of the gas produced.

LII.

Carbon.

As in the preceding process the coal became lighter, and as upon an accurate examination it appears, that 28 parts of the coal were absorbed by 72 parts of oxygen gas, and that from both there was produced one hundred parts of the gas before mentioned, it necessarily follows, that, in the combustion of the coal, something is disengaged from it, which combines with oxygen gas; this is what has been distinguished by the name of Carbon.

LIII.

As this substance cannot be exhibited by itself, we are forced to examine it more accurately in its combinations with bodies already known.

The most remarkable among these is its above-mentioned combination with
oxygen,

oxygen, which, because it possesses the property of an acid, is termed Carbonic acid gas.* Its synonymous names are, Fixed Air, Mephitic Air, Aerial Acid.

LIV.

Its Preparation.

The mode before mentioned (LI.) is too troublesome. We find it ready formed in nature, chiefly combined with lime, in the form of lime-stone, chalk, &c. from which it may be separated by acids that have a greater affinity with it, or by exposure to a strong heat.†

LV. *Its*

* We are indebted for its discovery to the late Dr. Black of Edinburgh. T.

† It is much to be regretted that we are not acquainted with a cheap method of separating the carbon from its combinations with lime, &c. The immense chains of lime hills which abound in almost every country, and form, as it were, the shell

LV.

Its Properties.

1. It is unfit for combustion and animal respiration.

2. It readily unites with water, to which it communicates an acidulous taste. Upon this circumstance is founded the artificial imitation of acidulous waters, by means of Nooth's apparatus.

3. In other respects it is similar to all other acids.

4. It is considerably heavier than atmospheric air.*

shell of our globe, might, in that case, abundantly supply us with fuel, and prevent the necessity of using wood for that purpose, where pit-coal is not readily had. T.

* Its specific gravity to that of the atmosphere is about 1500: 1000. A cubic inch weighs 0,68985 of a grain. T.

5. And

5. And is highly volatile.

LVI.

The presence of this gas in atmospherical air depends on circumstances favourable to its production. Hence its quantity is variable, and cannot therefore be accurately determined.*

LVII.

The properties of the diamond are exactly analogous to those of carbon.†
(L. LI.)

* Its proportion in the atmosphere, near the surface of the earth, is generally about two in a hundred, but in the higher regions it is far more abundantly ; for Messrs. Garnerin and Beauvais having ascended in an air balloon, and filled a jar with atmospherical air, at the distance of about 4000 feet above the surface of the earth, Mr. Humboldt, who analysed it, found it to be about five degrees more impure than the air of the earth's surface. T.

† On this subject *Vide* the transactions of the Royal Society for 1797. T.

II. Con-

II. *Concerning Water.*

LVIII.

Water possessing the property of dissolving various bodies, we seldom meet with it in nature perfectly free from adventitious matter. The gaseous substance before considered, is one of those bodies with which it is most commonly impregnated. Rain water contains moreover some portion of oxygen gas. Sometimes also it holds salts and earths in solution; to this circumstance is owing the difference between hard and soft water.

We obtain it pure by distillation.

LIX.

Decomposition of Water.

If pure water be treated in a higher temperature, with oxidifiable bodies,
such

such as metals (iron) for instance, we perceive,

1. That a gas is generated which is very light and inflammable.

2. The oxidifiable body is oxidated.

3. The whole of the water disappears.

4. The oxidifiable body encreases in weight.

5. The encrease of weight in the oxidated body, and the weight of the gas recently produced, is precisely equal to the weight of the water which has disappeared.

If water be subjected to the same treatment with charcoal, we obtain carbonic acid gas and the inflammable gas above mentioned, which, together,

K

are

are equal in weight to the loss of the coal and of the water.

LX.

Inferences.

1. The oxidation of a body (calcination of a metal) is owing to the presence of oxygen. Water, therefore, contains oxygen.

2. From LIX, 5; it follows, that it contains, likewise, another constituent, which was disengaged in the state of gas. (LIX. 1.)

LXI.

Generation of Water.

The foregoing conclusions are founded on the evidence of facts; for it is proved by a great number of experiments, that, whenever the gas above mentioned
(LIX, 1.)

(LIX, 1.) and oxygen gas, are burnt, the product is water. By the union of 15 parts (by weight) of the former, and 85 parts of the latter, 100 parts of water are produced.

LXII.

Generator of Water, or Hydrogen.

The other essential constituent of water cannot be exhibited by itself in a solid or visible state; for, when disengaged from its combinations, it exists merely as a light and inflammable gas. As it possesses the peculiar property of producing water, when combined with oxygen, it is considered as a distinct substance, and termed hydrogen,* or generator of water.

* From *ὕδωρ* aqua and *γεννομαί* gignor.

LXIII.

Hydrogen Gas.

We obtain it likewise by the solution of metals in acids, diluted with water, on which occasion the water is decomposed in the same manner as before observed. (LIX.)

Besides the characteristic of this gas, (LIH.) it is further distinguished by the following properties:

1. It is readily inflamed, the smallest electrical spark being sufficient for this purpose*.

The

* As the property of burning which this gas possesses in common with all other combustible bodies, is merely the power of decomposing atmospheric air, and carrying off its oxygen from the caloric, with which it is combined, we may readily conclude, that it cannot burn unless atmospheric

The construction of electrical lamps depends upon this property of hydrogen gas.

When combined with atmospherical air, or rather with pure oxygen gas, it explodes with a loud report.

2. It is the lightest of all gases.* Hence its utility in aerostation, air balloons depending greatly upon the application of this gas.

3. It has not any acid properties, and is void of taste and smell.

4. It is unfit for respiration; and, in the gas itself, no combustible body can burn.

mospherical air or oxygen gas be present. Hence if fire be set to a bottle full of this gas, it burns gently, first at the neck of the bottle, and then in the inside of it, in proportion as the external air gets in.—*Vide Lavoisier.* T.

* Atmospherical air is about thirteen times heavier than hydrogen gas. T.

It

It is generally known by the name of Inflammable air.

*Application of the preceding Experiments
to other Phenomena.*

LXIV.

I. *Detonation.*

If nitre or salt-petre, chemically termed nitrate of potash (XXXVI.) be burnt over a strong fire, and then brought into contact with oxidifiable substances, (carbon, sulphur, metals, &c.) a loud report will accompany the inflammation of these bodies. This is termed *Detonation*. The vegetable alkali, or potash, of the nitre, and the oxidated substance, remain, nitrogen gas being disengaged. The nitric acid of the salt-petre is also decomposed.

LXV.

II. *Gunpowder.*

The combustion of this mixture of salt-petre, charcoal, and sulphur,

phur,* depends likewise upon the decomposition of the former, by means of the two latter. The great elasticity of the nitrogen and carbonic acid gases, at the instant of their disengagement, accounts for the tremendous power of gunpowder when inflamed in close vessels.

FOURTH SECTION.

Examination of Compound Inflammable Gases.

LXVI.

Hydrogen gas has the property of dissolving various substances, as carbon, sulphur, phosphorus, oils, &c. the nature of the gas being thus changed.

* Gunpowder consists of about 75 parts nitre, 10 parts sulphur, and 15 charcoal. T.

I. Carbonated

I. *Carbonated Hydrogen Gas.*

LXVII.

During the decomposition of organized bodies, by fire, we obtain a gas, which is inflammable, and of an unpleasant empyreumatic smell.

LXVIII.

It differs from pure hydrogen gas by its being heavier, and by its denser and deeper coloured flame on combustion.

LXIX.

Its combustion with oxygen gas, in closed vessels, is productive of water and carbonic acid. It therefore consists (according to LXI. and LI.) of carbon and hydrogen; whence it is termed, Carbonated Hydrogen Gas.

II. *Sulphurated*

II. *Sulphurated Hydrogen Gas.*

LXX.

If sulphur be heated in pure hydrogen gas it will be dissolved, and a peculiar gas will be obtained. It is generally prepared by the solution of sulphate of potash, or liver of sulphur, in acids diluted with water.

LXXI.

Its Properties.

1. It possesses a very disagreeable smell.

2. It is unfit for respiration, and a lighted taper ceases to burn in it; but it is itself inflammable.

3. It is readily absorbed by water, especially if cold.

4. Although it be not sour to the taste, yet, in other respects, it resembles acids.

LXXII.

If this gas and oxygen gas be kept in a glass vessel carefully closed, we find, after some time, that the internal surface of the vessel is covered with a thin coat of sulphur, and also a small quantity of water, which proves it to be composed of sulphur and hydrogen, whence it is distinguished by the name of Sulphurated hydrogen gas.

LXXIII.

Fulminating Powder.

The mixture known by the name of fulminating powder, which consists of three parts nitre, two parts alkali, and one part sulphur, possesses the singular property, that if but a small quantity of it be gradually heated in a ladle, till the sulphur inflames, it suddenly burns, accompanied by a violent report. This
arises

arises from the combustion of the fulminating gas, formed during the inflammation of the oxygen gas, the nitre, and the sulphurated hydrogen gas furnished by the sulphuret of alkali.

III. *Phosphorated Hydrogen Gas,*

LXXIV.

If phosphorus be heated in hydrogen gas, this gas, in dissolving the phosphorus, undergoes a complete change.

LXXV.

It is now distinguished by the property of instantly inflaming on the contact of atmospherical air. This effect is produced still better by means of oxygen gas. It has, besides, a very disagreeable smell similar to that of garlic.

Synonymous terms are, Gas of phosphorus, Air of phosphorus, Phosphorated hydrogen gas.

LXXVI.

It is prepared with less trouble by treating the water and phosphorus in combination with alkalis, by which means the water is more readily decomposed by the phosphorus.

LXXVII.

Finally, if by direct exposure to a strong heat we effect a combination of phosphorus and lime(phosphoret of lime) and then throw it into water, a great number of bubbles are formed, which inflame at the surface of the water, on contact with the atmosphere,

APPENDIX.

LXXVIII.

In like manner phosphorus may be dissolved in nitrogen gas, thus forming a gas which, by means of water and acids, becomes luminous.

LXXIX. Hy.

LXXIX.

Hydrogen gas also dissolves oils and some metals (arsenic for instance) and is thus changed in its properties.

LXXX.

The mixture of spirit of wine, and sulphuric acid, is productive of an inflammable gas, which possesses the peculiar property of assuming the form of oil, on the contact of muriatic acid gas.

IX. *Ammoniacal Gas.*

LXXXI.

If sal ammoniac and lime be heated in a pneumatic apparatus, a new combination takes place, muriate of lime is formed, and an inflammable gas, viz. ammoniacal or volatile alkaline gas is disengaged.

LXXXII. This

LXXXII.

This gas is distinguished by the following properties:

1. Its action upon vegetable colours is similar to that of alkalis.

2. It readily combines with water, and forms what is termed, Caustic Spirit of Sal Ammoniac.

3. It is lighter than atmospherical air.

4. It is soluble in oxygen gas, atmospherical air, nitrogen gas, &c.

5. But if brought into contact with acid gases, for instance, carbonic acid gas, and heated, both gases lose their aerial form, and become concrete.

LXXXIII.

If burnt with oxygen gas the product of the combustion is nitrogen gas and water.

LXXXIV. As

LXXXIV.

As on this occasion the nitrogen and hydrogen appear separately, and as these bodies are not contained in oxygen gas, it necessarily follows that they are derived from the ammoniacal gas; this gas consists, therefore, of nitrogen or azot, and hydrogen. One hundred parts contain about eighty of the former.

Application of these Facta to the Explanation of some Phenomena.

I. *General Law of Deoxygenation.*

LXXXV.

Deoxygenation is best effected, if the oxidifiable body be exposed to the influence of oxygen in combination with other substances, rather than if simply so exposed.

LXXXVI. Hence,

LXXXVI.

Hence, the two gases last mentioned are more fit for this purpose than pure hydrogen gas; thus also pyrophori, which are compounds of carbon, sulphur, and alkali, and Canton's, Baldwin's, or Bononian phosphori, do more or less accelerate the process of deoxygenation.

II. *Nature of Compound Acids.*

LXXXVII.

If acetite of potash, or the salt formed by the combination of the acetous acid or radical vinegar, and potash, be subjected to dry distillation, we obtain carbonic acid and hydrogen gas; the alkali alone remains behind. The weight of the gases obtained is precisely equal to the weight of the radical vinegar, which has disappeared.

LXXXVIII. The

LXXXVIII.

The following acids are changed into acetous acid, or radical vinegar, when treated with nitric acid: the tartareous acid, the oxalic acid, the citric acid, the malic acid, the benzoic acid, the gallic acid, the formic acid, the saccho-lactic acid, the sebacic acid, and the acid of amber. The nitric acid is decomposed, and nitrous gas (XXXVIII.) comes over. The acids just enumerated admit, likewise, of a gradual and reciprocal change. Thus the tartareous acid may be converted, first into oxalic acid, and then, by means of a greater quantity of nitric acid, into radical vinegar, or the acetous acid.

LXXXIX.

These acids seem, therefore, to be of the like nature, which is evident, moreover, from this circumstance—that when

M

singly

singly decomposed, they appear analogous to vinegar. (LXXXVII.)

XC.

Hence their bases (XXXI.) consist of carbon and hydrogen.

XCI.

They differ from each other by reason of the unequal quantity of oxygen with which their bases are united*.

XCII.

Some animal acids† differ from those above mentioned merely in this, that their radical contains azot or nitrogen, as well as carbon and hydrogen.

* May not the proportion of hydrogen and carbon also vary very materially? T.

† The number of acids obtained from animal matter has lately been increased by the *Zoonic acid*. —*Vide the Annales de Chimie, vol. XXVI.* T.

XCIII. For

XCIII.

For if animal coal and alkali be exposed to a strong heat, and then decomposed, by means of the sulphuric acid, we obtain an inflammable gas, which possesses the following properties: It has a sharp taste and pungent smell; it is absorbed by cold water, but, being exposed to the atmosphere or heat, it evaporates; combined with an alkali, or earth, it throws down a blue precipitate in a solution of iron; and finally, it possesses some properties in common with acids, whence it is termed, the Prussic acid. Its combustion with oxygen gas furnishes carbonic acid, water, and what was not obtained from the acids above mentioned, (LXXXVII.) nitrogen gas.

XCIV.

The uric acid,* with respect to mixture, is similar to this.

* This acid has, till lately, been termed the *lithic acid*. T.

III. *Composition of some inflammable Bodies.*

XCIV.

1. *Spirit of Wine.*

The products of the combustion of this body in pure oxygen gas are, carbonic acid and hydrogen gas. Its constituent parts are, therefore, hydrogen and carbon.

XCVI.

Spirit of wine, when treated with acids, forms Ether and a compound acid. (LXXXVIII.)

2. *Oils.*

XCVII.

Fixed oils, by repeated distillation, become partly volatile.

XCVIII. When

XCVIII.

When burnt in oxygen gas they exhibit the same phenomena as spirit of wine (XCV.) But on this occasion they afford a greater abundance of carbonic acid; and among oils the volatile yield the greatest proportion of water. Ethereal, or volatile oils, contain, therefore, more hydrogen than fixed, or fat oils.

XCIX.

Oils, by being treated with acids,* become inspissated; fixed oils are changed into a substance similar to wax; volatile oils into resins, and both, at length, into compound acids.

IV. *Constituent Parts of organized Bodies.*

C.

Bodies exposed, in close vessels, to a degree of heat not exceeding that of boiling water, furnish, if

* Particularly the oxyginated muriatic. T.

Vegetable.

*Vegetable.**Animal.*

Water.

Water and ammoniac.

Volatile oil.

Empyreumatic oil.

Carbon.

Carbon.

On Exposure to a red Heat.

Carbonic acid gas.

Carbonic acid gas.

Hydrogen gas.

Hydrogen gas.

An acid approaching to
the acetous acid.Ammoniac with an em-
pyreumatic oil.

Carbon.

Carbon.

Burnt in Contact with Atmospheric Air.

Water.

Water.

Carbonic acid.

Carbonic acid.

Nitrogen gas.

A loose
residue,
consist-
ing of

$$\left\{ \begin{array}{l} \text{alkali,} \\ \text{earths,} \\ \text{metallic} \\ \text{oxides.} \end{array} \right.$$

A firm
residue,
consist-
ing of

$$\left\{ \begin{array}{l} \text{Phosphoric acid.} \\ \text{Lime.} \end{array} \right.$$

CI.

On a comparison of these products it follows, that vegetable and animal bodies differ from each other with respect to
their

their constituent parts, of which most are the same, in as much as the latter contain some substances not to be met with in the former, as nitrogen and phosphorus.

V. Mixture of the constituent Parts of organized Bodies.

CII.

Those constituents of organized bodies, hydrogen, oxygen, carbon, and nitrogen, all essential to their form and existence, are so combined as to produce a tranquil and equipoized whole. Every interruption of this equilibrium causes a change, and at length the harmony of the system ceases. All circumstances tending to encrease or diminish the proportion of the parts thus organized, produce their total separation, and urge them to enter into new combinations. As these changes are induced by oxidation,

dation, and cannot therefore be perceived till its effects become visible, they are termed, Spontaneous changes in the mixture of the constituent parts of organized bodies.

CIII.

Water, heat, and atmospherical air, co-operate to produce this change.

CIV.

Vegetables, containing sugar, develop under those circumstances, while their temperature encreases, carbonic acid gas. Their earthy particles, together with a small portion of carbon, hydrogen, and oxygen, are separated, and, at length, these phenomena terminate in the production of a vinous liquor, of which the chief constituent is vinous spirit. If we continue to expose this product to the agency of those conditions

tions (CIII.) we obtain under similar, but stronger appearances, that liquid termed Vinegar. Finally, after bodies, especially if animal, have further experienced the effect of the above causes, they putrefy, and thus terminates their destruction. During this operation they develop carbonic acid gas, hydrogen gas, and ammoniac, combined with sulphur, carbon, and phosphorus.

CV.

The effects of oxidation are, therefore, in reality at all times the same, though the phenomena which accompany them seem to differ.

VI. *Respiration.*

CVI.

a. *Of Animals.*

It is not only certain than no animal can live without the presence of atmos-
N
pherical

spherical air, and that life is therefore analogous to flame, but also, that oxygen gas, when inspired, thus contributing to the prolongation of life, undergoes the same change in its properties as during the combustion of charcoal. (LI.) We observe this in the blood, both in the lungs and on the surface of the skin, exposed to the influence of the atmosphere.

Hence, when we respire, the carbon, collected in our body, is separated, while, at the same time, a considerable portion of hydrogen, combined with oxygen, in the state of water, escapes in the form of vapour.

CVII.

b. *Of Vegetables.*

It is very different with plants, which, in a higher temperature, seem to disengage by means of their leaves, or organs
of

of respiration, the oxygen collected in them when in a lower temperature.* Their aliments are in other respects analogous to those of animals.†

* According to Ingenhouz, Jacquin, and others, they disengage oxygen in the light and carbonic acid in the dark. T.

† It has been proved by various and accurate experiments, that oxygen has a very powerful influence on vegetation. Humboldt tried experiments upon cresses, which in oxigenated muriatic acid gas, mixed with water, shewed germs at the end of three hours; in common water, on the contrary, not till at the end of thirty-two hours. Jacquin and Vander Schott, at Vienna, threw into oxigenated muriatic acid, all the old seeds which had been kept twenty or thirty years at the botanical garden, every attempt to produce germination in which had proved fruitless, and the greater part of them were stimulated with success. Plants, sprinkled with water, previously impregnated with oxygen gas, do not only become more vigorous, but display more beautiful tints. These discoveries cannot fail of proving highly useful to gardeners and botanists. T.

FIFTH SECTION.]

*Nature of Acid Gases.*I. *Sulphurous Acid Gas.*

CVIII.

The combustion of sulphur produces the sulphuric acid, in consequence of its union with oxygen. But, if a sufficient quantity of oxygen gas be not present, the acid produced is said to be imperfect acid of sulphur, or sulphurous acid. This acid is obtained by the deoxygenation of the sulphuric acid, by means of oxidifiable bodies, as carbon, oils, metals, &c.

CIX.

It possesses a suffocating sulphureous smell, and a weak acid taste. It not
only

only changes the colour of plants, but destroys it. On exposure to the atmosphere it becomes sulphuric acid. Hence in contact with it, a cloud is immediately produced.

CX.

It readily combines with the sulphuric or the perfect acid of sulphur, and forms what is denominated Fuming oil of vitriol.

II. *Phosphorous Acid Gas.*

CXI.

During the inflammation of phosphorus, in atmospherical air, a gas is formed, whose smell is similar to that of garlic, and which, when exposed to the atmosphere, forms white and suffocating vapours, which are luminous in the dark, and which are then converted into phosphoric acid.

III. *Mu-*

III. *Muriatic Acid Gas.*

CXII.

During the decomposition of culinary salt, chemically termed muriate of soda, there escapes a very suffocating gas, which, in contact with atmospherical air, or ammoniacal gas, forms white fumes; these, when absorbed by water, constitute the Muriatic acid.

CXIII.

Sal Ammoniac.

If muriatic acid gas, and ammoniacal gas, be mixed, they lose, while heated, their gaseous form, and become a salt, commonly termed Sal Ammoniac, but properly, Muriate of Ammoniac.

IV. *Oxygenated Muriatic Acid Gas.*

CXIV..

Its Formation.

By combining the muriatic acid gas, before mentioned, with an additional
portion

portion of oxygen, it obtains properties quite different. This is effected either by heating the muriatic acid with metallic oxides, or, by decomposing muriate of soda by the sulphuric acid, and, at the same time, causing the gas, which comes over, to come into contact with the oxides of metals.

Thus yellowish fumes are developed of an extremely pungent taste and smell, distinguished by the name of Oxigenated muriatic acid gas, which is synonymous with Dephlogisticated acid of salt.

CXV.

Its Properties.

1. These vapours, so exceedingly noxious to the lungs, are not in reality a gas, for, when exposed to the cold, they become a solid inspissated mass, which, on exposure to heat, expands into an elastic fluid.

2. Ani-

2. Animals die in it very suddenly.

3. A lighted taper continues to burn in it with a diminished and darker flame, and phosphorus, carbon, cinnabar, antimony, bismuth zinc, and various other combustible bodies, burn in it spontaneously.

4. It entirely destroys all vegetable colours.

5. All metals are soluble in it.

6. A mixture of those vapours, and hydrogen gas, may be inflamed, in which case their combustion is accompanied by a loud report, and the formation of liquid muriatic acid.

7. Nitrous gas (XXXVIII.) immediately produces a cloud of reddish vapours with it, which become nitrous (XXXIX.) and muriatic acid.

8. Ammoniacal gas (LXXXI.) causes a kind of combustion with it, which
is

is productive of azotic gas, water and muriatic acid.

9. It is gradually absorbed by water, but in less quantity if warm.

10. It is decomposed by the influence of the sun's rays; oxygen gas is developed and the muriatic acid remains.

CXVI.

Its remarkable Combinations.

Among these, that with alkalis is peculiarly distinguished.

These combinations are not merely capable, like the salts produced by the nitric acid, of detonating (LXIV.) with inflammable substances, but they are also remarkable for the following properties.

0

1. If

1. If the oxy-muriate of potash be rubbed between two hard bodies it dissilates and emits sparks.

2. Thrown into sulphuric acid it causes a strong report, accompanied by a dark red light, and the liquid, together with the salt, is scattered in every direction.

3. Three parts of oxy-muriate of potash or soda, and one part of sulphur, pounded in a mortar, produce many and successive detonations, as loud as the report of a pistol, or even of a musket, according to the celerity of the motion, or the force of the pressure applied.

4. If about a grain of this mixture be put upon an anvil, and strongly beat with an hammer, a report is produced equal to that of a musket, and a stream
of

of light, of a purple colour, is seen round the anvil.

5. Immersed in sulphuric acid, the mixture suddenly inflames and burns without report, and with a white dazzling flame.

6. A similar effect is produced by a mixture of this salt and charcoal, antimony, zinc, sugar, gum, oils, &c.

7. If triturated with phosphorus, a very violent explosion is produced, accompanied by flame.

It has lately been discovered, that nitrates act in the same manner.

This salt, when distilled by a gentle heat, furnishes pure oxygen gas, and changes into muriate of potash or soda.

V. *Fluoric Acid Gas.*

CXVII.

Its Formation.

Fluor Spar is decomposed by the sulphuric acid. This acid combines with the lime of the spar, while the other constituent of this body escapes in the form of a gas, termed Fluoric acid gas.

CXVIII.

Its Properties.

1. On the contact of atmospherical air it changes into whitish fumes.

2. If a plate of glass be suspended over these fumes, its surface is immediately affected; it loses its polish, becomes opaque, and the glass is actually corroded*. In this property it differs

* On account of this property it has been employed with great success in ornamenting glass vessels with flowers, animals, landscapes, &c. T.

from

from all the other gases before treated of. If, therefore, we distil it from a glass retort, and bring it in contact with water, it immediately deposits a siliceous crust.

3. It is heavier than atmospherical air.

4. It renders lime water turbid; the precipitate produced on this occasion consists of fluor spar.

*Application of the Properties of the Bodies
just treated of.*

I. *Bleaching.*

CXIX.

As the process of bleaching is founded on the destructibility of vegetable colours, and as this is completely effected by the oxygenated muriatic acid, this acid has been employed with the best
success,

success, for the bleaching of various substances*.

II. *Aqua Regia.*

CXX.

This liquor is produced by the mixture of four parts of muriatic acid and one part of nitric acid. On this occasion the muriatic acid deprives the nitric acid of part of its oxygen, and thus becomes oxigenated, while nitrous gas is developed.

* Vide Mr. Chaptal's process, described in the second volume of the *Bulletin des Siences*; and Mr. Rupp's, described in vol. V. of the *Memoirs of the Literary and Philosophical Society of Manchester*. T.

FINIS.

